EFFECT OF PERFORATIONS ON COLD-FORMED STEEL BUILT-UP I-SECTION

WAN MOHAMAD IZZUAN BIN WAN KAMALUDIN

B. ENG(HONS.) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering

____

(Supervisor's Signature)

Full Name : ENCIK KHALIMI JOHAN BIN ABD HAMID

Position : LECTURE

Date : 25 JUNE 2018

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

(Student's Signature)

Full Name : WAN MOHAMAD IZZUAN BIN WAN KAMALUDIN

ID Number : AA14171

Date : 25 JUNE 2018

EFFECT OF PERFORATIONS ON COLD-FORMED STEEL BUILT-UP I-SECTION

WAN MOHAMAD IZZUAN BIN WAN KAMALUDIN

Thesis submitted in fulfillment of the requirements
for the award of the
Bachelor Degree in Civil Engineering

Faculty of Civil Engineering and Earth Resources
UNIVERSITI MALAYSIA PAHANG

JUNE 2018

ACKNOWLEDGEMENTS

Praise and glory to Allah S.W.T, God of all creations and greeting and salutations we bring forth to our Prophet Muhammad S.A.W for supervising this final year project and constantly guiding this project towards completion.

I want to express my gratitude to my beloved family for the indirectly supports given and commitments in this project, for their efforts to help me in the completion of this final year project. My mother and father are the important persons in my life, because of them; I was raised to believe that I can do anything if I put my mind to it.

My sincere thanks to my supervisor Encik Khalimi Johan Bin Abd Hamid for him germinal ideas, invaluable guidance, continuous encouragement and constant support in making this final year project possible. He has always impressed me with him outstanding professional conduct and him strong conviction for engineering knowledge. I attribute the level of my Bachelor Degree to him encouragement and effort and without him, this thesis would not have been complete.

Last but not least, I am deeply thanks to my friends Ruzaim Ruslan, Izzudin Harisfazil and Hafizi Dalha for their helps and supports in everything that I do, especially in the time completing my study. Thank you so much.

ABSTRAK

Keluli sejuk terbentuk mempunyai pelbagai jenis bentuk berdasarkan fungsi mereka dalam kerja pembinaan. Terdapat tiga jenis bentuk iaitu bentuk terbuka tunggal, bentuk tertutup dan bentuk bina terbuka. Kajian ini menumpukan kepada bentuk bina terbuka. Struktur keluli sejuk terbentuk biasanya datang dengan kehadiran tebukan. Fungsi tebukan lubang atau bukaan yang dibuat pada keluli terbentuk sejuk untuk memudahkan kerja pembinaan. Ia biasanya disediakan dengan pelbagai bentuk dan saiz berdasarkan fungsinya seperti untuk menampung elektrik, paip dan penghawa dingin atau pemanas. Walau bagaimanapun, kehadiran tebukan boleh menyebabkan pengurangan kekuatan elemen komponen individu dan kekuatan keseluruhan anggota itu bergantung kepada kedudukan, saiz dan orientasi pembukaan. Kajian ini akan memberi tumpuan kepada kesan kedudukan dan bentuk tebukan pada kekuatan struktur tiang keluli terbentuk sejuk yang paksi dimuatkan. Satu siasatan experimen untuk keluli sejuk terbentuk tertakluk kepada mampatan loading untuk mengkaji kesan tebukan pada kapasiti beban ahli lajur terbina I-seksyen diadakan. Sebanyak 8 sampel yang mempunyai kedudukan tebukan yang berbeza telah diuji dalam eksperimen ini. Setiap ahli mempunyai ketebalan nominal sebanyak 1.2 mm, panjang 600 mm dan telah dimampatkan. Hasil daripada eksperimen ini menunjukkan bahawa beban muktamad setiap sampel amat berbeza pada kedudukan tebukan. Keputusan ini dipersembahkan dalam tiga bahagian yang beban vs anjakan menegak, beban vs anjakan mendatar dan tingkah laku lengkungan.

ABSTRACT

Cold-formed steel comes with various type of section based on their function and purpose in construction work. There are three main types of sections which are single open section, open built-up section and closed built-up section. This research will be concentrating on open built-up section or I-section. Structural members of cold-formed steel usually come with the presence of perforations. Perforations are a hole or opening that are made on the cold-formed steel to ease construction work. It usually provided with different shapes and size based on its function such as to accommodate electrical, plumbing and air conditioner or heating services. However, the presence of perforations may cause a reduction in strength of individual component elements and the overall strength of the member depending on the position, size and orientation of the opening. This research will focus on the effect of position and shape of the perforations on the structural strength of the axially loaded cold-formed steel column. An experimental investigation of cold-formed steel subjected to compression loading to study the effect of perforations on the load capacity of column members of built-up I-section is held. A total of 6 samples that have different position of perforations were tested in this experiment. Each member has nominal thickness of 1.2 mm, column length of 600 mm and was compressed between a simply supported ends at both end. The result of this experiment shows that the ultimate load of each sample varies greatly on the perforation position. The result is presented in three sections which are load vs vertical displacement, load vs horizontal displacement and buckling behavior.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CFS	Cold-formed steel
CRS	Cold-rolled steel
FKASA	Fakulti Kejuruteraan Awam & Sumber Alam
UMP	Universiti Malaysia Pahang
mm	millimetre
UTM	Universal Testing Machine
LT	Local buckling at top
LM	Local buckling at middle
LB	Local buckling at bottom
DTf	Distortional buckling at top (front)
DTb	Distortional buckling at top (back)
DMb	Distortional buckling at middle (back)
DMf	Distortional buckling at middle (front)
DBf	Distortional buckling at bottom (front)
DBb	Distortional buckling at bottom (back)
WTf	Warping Buckling at top (front)
WTb	Warping Buckling at top (back)
WMf	Warping Buckling at middle (front)
WMb	Warping Buckling at middle (back)
WBf	Warping Buckling at bottom (front)
WBb	Warping Buckling at bottom (back)
FE	Finite Element
CH1	Transducer 1 - Vertical Displacement
CH2	Transducer 2 – Horizontal Displacement
CH3	Transducer 3 – Horizontal Displacement

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Cold steel products, such as bar stocks and cold steel sheets, are typically used in all areas of durable goods manufacturing, such as equipment or cars, but cold-formed steel phrases are most commonly used to describe construction materials. In the construction industry these two structural and structural elements are made of thin steel gauges. These building materials include columns, beams, loops, buttons, floor deck, built-in parts and other components as shown in Figure 1.1. Cold construction materials are cold-formed from other steel construction materials known as hot-rolled steel. Production of cold-formed steel products occurs at room temperature using rolling or pressing.

Built-up cold formed steel is usually a regular composition of normal cold formed steel such as C, Z, Sigma, or parts of the hat to produce new parts as shown in Figure 1.2. This part is connected using bolts, screws, or welding. The cold formed steel common build section used for compressors and members of tension. Built-up cold-formed steel products, such as bar stocks and cold steel sheets, are typically used in all areas of durable goods manufacturing, such as equipment or cars, but cold-formed steel phrases are most commonly used to describe construction materials. In the construction industry these two structural and structural elements are made of thin steel gauges. These building materials include columns, beams, loops, buttons, floor deck, built-in parts and other components. Cold construction materials are cold-formed from other steel construction materials known as hot-rolled steel. Production of cold-formed steel products occurs at room temperature using rolling or pressing.

Figure 1.1 Building made up from the cold-formed steel

Source: Steel Study Company (SCAFCO) (2014).

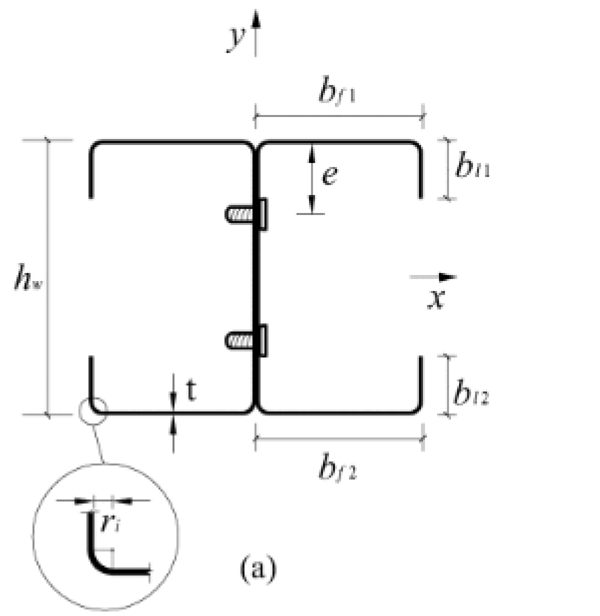

Figure 1.2 Build-up cold-formed steel C-section

Source: Marino Ware Company (2009).

1.2 Problem Statement

Members of the cold formed steel structure are usually produced with holes to accommodate pipelines, electricity, and heating in walls and building ceilings. However, the special properties of steel formed by cold members require special consideration when it comes to applications under construction. Due to the various opening arrangements, some special research tasks to provide practical designs should be carried out where stability and strength may be mitigated by perforation. Many problems have increased due to existing openings as the design process will become more complicated and require additional expert reviews and has resulted in a collapse of the building. This leads to the use of cold-formed steel with openings in a limited industry and this can be changed with many studies by experts.

Cold-formed steels with openings have their own advantages and disadvantages to their own columns and structures. Opening can be found in the desired opening, especially in circles, rectangles, oval or rectangles. The existence of the opening will reduce the area of the cold and theoretically formed steel surface, its strength may be reduced to a cold formed form without opening. Perfection due to residual pressure due to folding cold-formed steel is among the issues in this study. The resulting pressure pressures are inevitable because during cooling, some stresses need to be used to make the desired shape cold.

1.3 Research Objective

The main aim of this research is to study the condition of build-up cold formed steel I-section under compression. In order to achieve this, several objectives are identified as follows:

i. To determine the ultimate load of cold-formed steel built-up I-section short column.

ii. To investigate experimentally the effects of various perforation position of cold-formed steel built-up I-section.

REFERENCES

Chen, W.F. & Liew, J.Y.R., 2003. The Civil Engineering Handbook. In *Civil Engineering*. China. pp.46-66.

Chen, J., YongHe & Wei-LiangJin, 2016. Stub column tests of thin-walled complex section with intermediate stiffeners. *Thin-Walled Structures*, pp.423–29.

Crisan, A., Ungureanu, V. & Dubina, D., 2012. Behaviour of cold-formed steel perforated sections in compression.Part 1—Experimental investigations. *Thin-Walled Structures*, pp.1-11.

Cristopher, D.M. & Schafer, B.W., 2009. Elastic buckling of cold-formed steel columns and beams with holes. *Engineering Structures*.

Georgievaa, I., Schueremansa, L., Vandewallea, L. & Pyla, L., 2012. Design of built-up cold-formed steel columns according to the direct strength method. *Procedia Engineering*, pp.119 – 124.

Haidarali, M.R. & David, A.N., 2012. Local and distortional buckling of cold-formed steel beams with edge-stiffened flanges. *Journal of Constructional Steel Research*, pp.31-42.

Jakab, G. & Dunai, L., 2008. Resistance of C-profile cold-formed compression members: Test and standard. *Journal of Constructional Steel Research 64*, pp.802–07.

Kulatunga, M.P. & Macdonald, M., 2013. Investigation of cold-formed steel structural members with perforations of different arrangements subjected to compression loading. *Thin-Walled Structures*, pp.78-87.

Kulatunga, M.P., Macdonald, M., Rhodes, J. & Harrison, D.K., 2014. Load capacity of cold-formed column members of lipped channel cross-section with perforations subjected to compression loading – PartI:FE simulationand test results. *Thin-WalledStructures*, pp.1-12.

Kwon, Y.B. & Seo, G.H., 2012. Prediction of the flexural strengths of welded H-sections with local buckling. *Thin-Walled Structures*, pp.126–39.

Liu, J.L., Dung, M.L. & Ching, H.L., 2009. Investigation on slenderness ratios of built-up compression members. *Journal of Constructional Steel Research*, pp.237–48.

Pedro, B.D., Eduardo, M.B., Dinar, C. & Eliane, S.d., 2012. Local–distortional–globa linteraction in lipped channel columns:Experimental results,numerical simulations and design considerations. *Thin-Walled Structures*, pp.2-13.

Quach, W.M., Teng, J.G. & Chung, K.F., 2010. Effect of the manufacturing process on the behaviour of press-braked. *Engineering Structures*, pp.3501–15.

Rondal, J., 2000. Cold formed steel members and structures. *Journal of Constructional Steel Research*, pp.155–58.

Sadovskýa, Z., Kriváčeka, J., Ivančob, V. & Ďuricovác, A., 2012. Buckling strength of lipped channel column with local/distortional interactions. *Procedia Engineering*, pp.399 – 404.

Schafer, B.W., 2008. Review: The Direct Strength Method of cold-formed steel member design. *Journal of Constructional Steel Research*, pp.766–78.

Schafer, B.W. & Ádány, S., 2005. UNDERSTANDING AND CLASSIFYING LOCAL, DISTORTIONAL AND GLOBAL BUCKLING IN OPEN THIN-WALLED MEMBERS. *Structural Stability Research Council Montreal*, pp.2-20.

Stone, T.A. & LaBoube, R.A., 2005. Behavior of cold-formed steel built-up I-sections. *Thin-Walled Structures*, pp.1805–17.

Sunil, M.H. & Patil, A.V., 2012. Study, test and designing of cold-formed section as per AISI code. *Int. Journal of Applied Sciences and Engineering Research*, 1(3), pp.522-31.

Tsavdarid, K.D. & D'Mello, C., 2011. Web buckling study of the behaviour and strength of perforated steel beams with different novel web opening shapes. *Journal of Constructional Steel Research*, pp.1605–20.

Wang, C., Zhang, Z., Zhao, D. & Liu, Q., 2016. Compression tests and numerical analysis of web-stiffened channels with complex edge stiffeners. *Journal of Constructional Steel Research*, pp.29-39.

Yao, Z. & Rasmussen, J.K., 2012. Inelastic local buckling behaviour of perforated plates and sections under compression. *Thin-Walled Structures*, pp.49–70.

Young, B., 2008. Research on cold-formed steel columns. *Thin-Walled Structures*, pp.731-38.

Young, B. & Chen, J., 2008. Design of Cold-Formed Steel Built-Up Closed Sections with Intermediate Stiffeners. *JOURNAL OF STRUCTURAL ENGINEERING*, pp.727-37.

Zhao, W., 2005. Behaviour and Design of Cold-formed Steel Sections with Hollow Flanges. *Cold-Formed Steel Structures*, pp.543-601.